20.15. ANCHORED SHEET PILE WITH FIXED-EARTH SUPPORT

Fig. 20.25 (*a*) shows the deflected shape of an anchored sheet pile with fixed-earth support. The elastic line changes its curvature at the inflexion point *I*. The soil into which the sheet is driven exerts a large

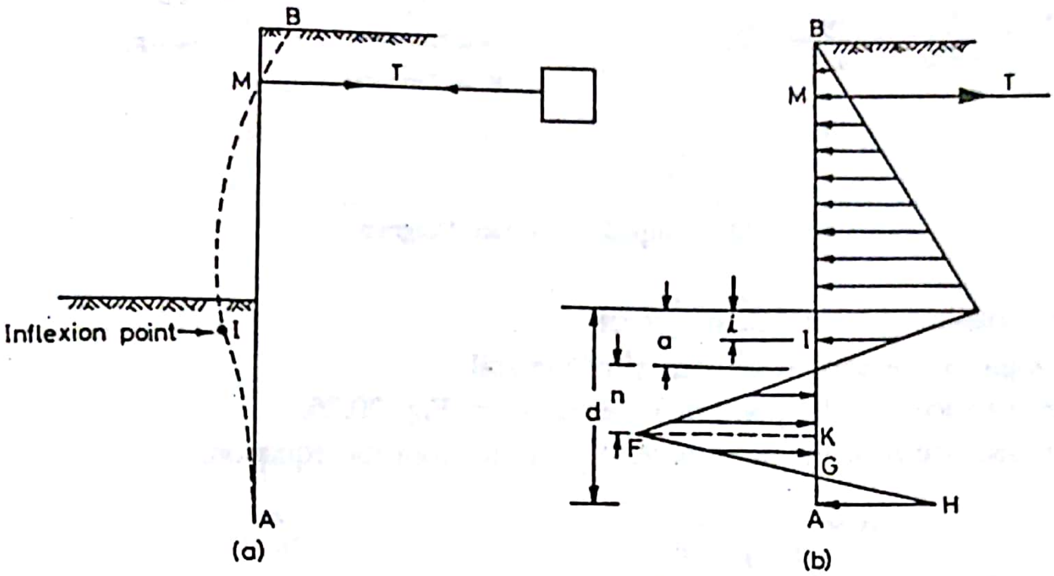

Fig. 20.25.

restraint on the lower part of the pile and causes a change in curvature. Fig. 20.25 (*b*) shows the pressure distribution. Blum (1931) gave a mathematical relationship between (i/h) and ϕ (Fig. 20.26), where i is the depth of the point of inflexion *I* below the dredge level and h is the height of sheet pile above the dredge level. Thus inflection point *I* is located.

For simplicity, the lower portion of the pressure diagram on the right hand side in Fig. 20.25 (*b*) is replaced by a concentrated force R_k at point *K* and the diagram shown in Fig. 20.27 (*a*) is used in the analysis. The magnitude of R_k is initially unknown, but it is automatically excluded from calculations when the moments are taken about *K*. Once the depth has been found, R_k can be determined from the equilibrium equation in the horizontal direction.

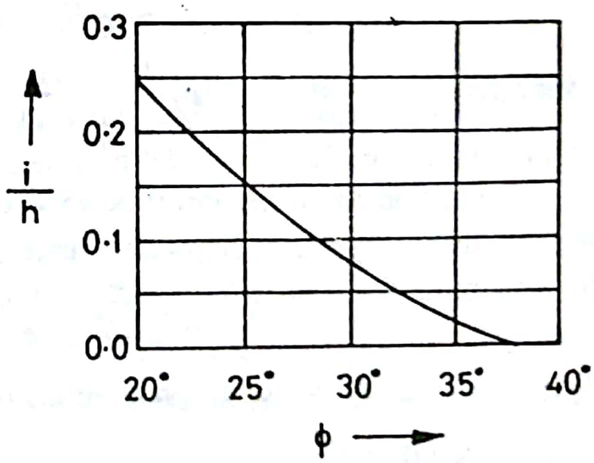

Fig. 20.26.

As the exact analysis of the anchored sheet pile with fixed-earth support is complicated, an approximate method, known as *equivalent-beam method* is generally used. It is assumed that the sheet pile is a beam which is simply supported at the anchor point *M* and fixed at the lower end *K*. Fig. 20.27 (*b*) shows the bending moment diagram. The bending moment is zero at the inflexion point *I*. Theoretically, the lower part *IK* of the pile can be removed and the shear force can be replaced by a reaction R_I. Thus, a simply-supported beam *BI* is obtained [Fig. 20.27 (c)].

The following procedure is used for the analysis of the sheet pile with fixed-earth support, using equivalent beam method.

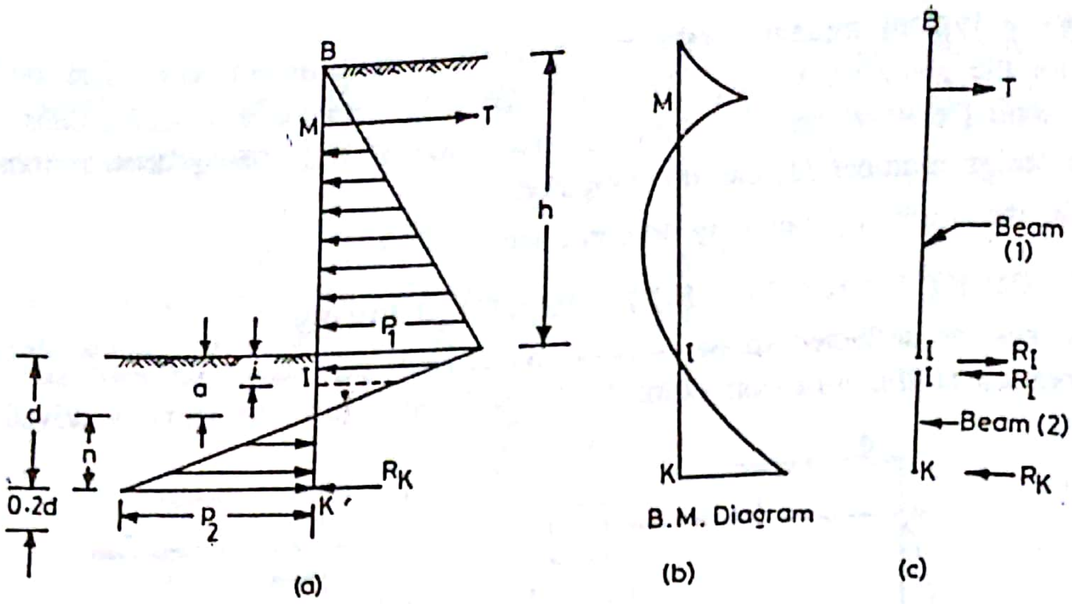

Fig. 20.27. Simplified Pressure Diagram.

(*a*) **Upper Beam BI**

(1) Determine the pressure p_1 at the dredge level.

(2) Estimate the angle of shearing resistance ϕ' of the soil.

(3) Determine the distance i of the point of inflexion from Fig. 20.26.

(4) Determine the distance a of the point of zero pressure from the equation,

$$a = \frac{p_1}{\gamma (K_p - K_a)} \quad \text{...(20.47)}$$

(5) Determine the pressure p_o at the point of inflexion from the relation,

$$p_o = \frac{p_1}{a}(a - i) \quad \text{...(20.48)}$$

(6) Determine the reaction R_I for the beam IB by taking moments about the point M of anchor of all the forces acting on IB [Fig. 20.28 (*a*)].

(*b*) **Lower Beam IK**

(7) Determine the pressure p_2 from the relation

$$p_2 = \gamma (K_p - K_a)(d - a) \quad \text{...(20.49)}$$

Alternatively, $$p_2 = \frac{p_o}{(a - i)} \times (d - a)$$

(8) Determine the distance $(d - a)$ by taking moments of the forces on the beam IK about K [Fig. 20.28 (*b*)] The reaction R_I on the lower beam is equal and opposite to that on the upper beam.

(9) Calculate d from Eq. 20.49 and hence find $D = 1.2\,d$.

(10) Determine the tension T in anchor by considering the equilibrium of beam IB. Thus

$$T = P_1 - R_I \quad \text{...(20.50)}$$

where P_1 = total force due to pressure on IB.

20.16. DESIGN OF ANCHORS

The anchors used in sheet pile walls are of the following types:

(1) Anchor plates and Beams (also, known as deadman) (Fig. 20.29).

(2) Tie backs.

(3) Vertical Anchor piles.

(4) Anchor beams supported by batter piles (Fig. 20.30).

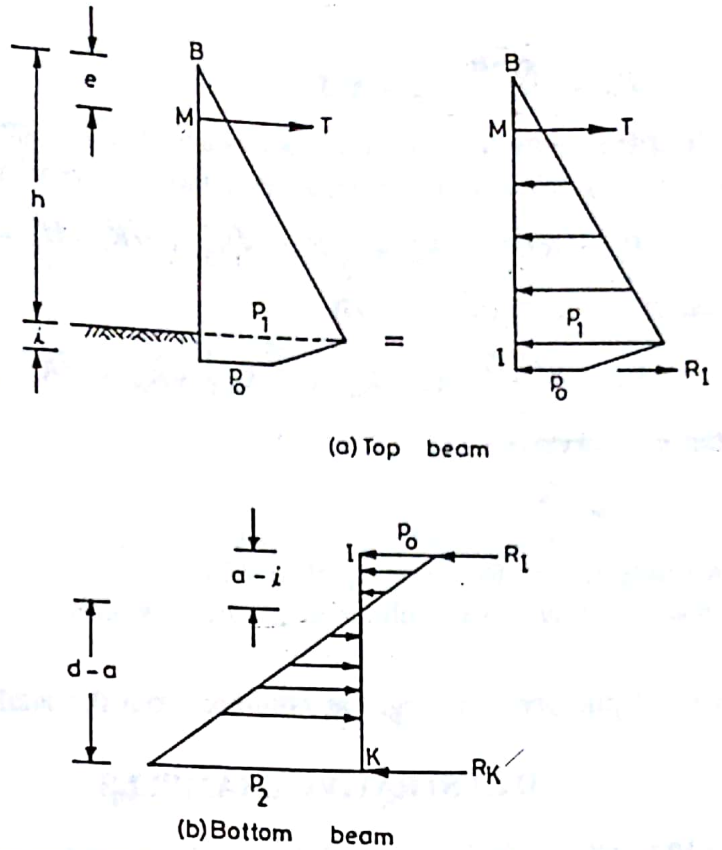

Fig. 20.28.

The design of anchor plates and beams is discussed below.

Anchor plates and beams are made of cast-concrete blocks. A wale (horizontal beams) is placed at the front (or back) face of the sheet pile, and a tie rod is attached to it. The other end of the tie rod is connected to an anchor plate or a beam (Fig. 20.29).

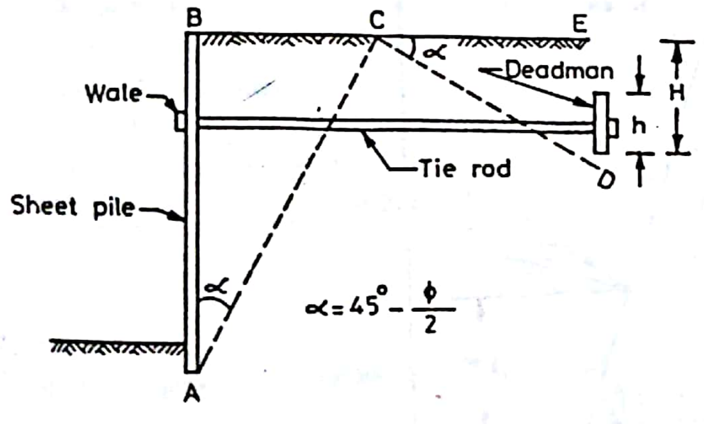

Fig. 20.29. Anchor Plates.

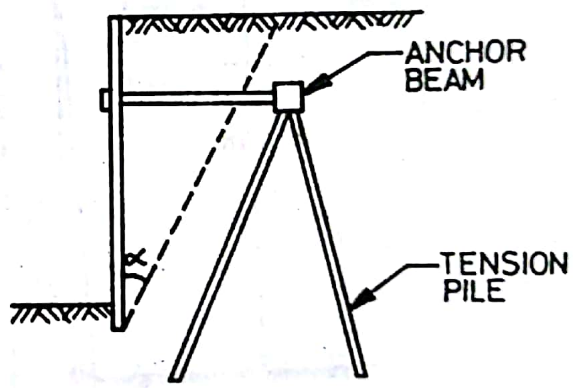

Fig. 20.30. Batter Piles.

The resistance offered by an anchor plate or a beam is derived from the passive resistance of the soil in front of the plate. For full passive resistance to develop, the anchor plate must be located in zone *CDE*. Teng (1962) gave the following equations for the ultimate resistance of anchor plates in granular soils located at or near the ground surface.

Let *B* be the length of the anchor perpendicular to the cross section and let *h* be the height of the anchor.

(*a*) For continuous plates or beams with $B/h \geq 5$, the ultimate resistance is given by

$$P_u = B\,(P_p - P_a)$$

or

$$P_u = B\left(\frac{1}{2}\gamma H^2 K_p - \frac{1}{2}\gamma H^2 K_a\right)$$

or $$P_u = \frac{\gamma H^2 B}{2}(K_p - K_a) \qquad ...(20.51)$$

where H is the depth of the lower face of the anchor beam from the ground surface.

(*b*) For plates or beams with $B/h < 5$, the ultimate resistance is given by

$$P_u = B(P_p - P_a) + \frac{1}{2}K_o \gamma (\sqrt{K_p} + \sqrt{K_o})H^3 \tan\phi$$

where K_o = coefficient of earth at rest (= 0.40).

Thus $$P_u = \frac{\gamma H^2 B}{2}(K_p - K_a) + \frac{1}{3}K_o \gamma (\sqrt{K_p} + \sqrt{K_o})H^3 \tan\phi \qquad ...(20.52)$$

The allowable resistance is taken as

$$P_a = \frac{P_u}{FS} \qquad ...(20.53)$$

where FS = factor of safety (generally taken equal to 2.0).

The centre-to-centre spacing of anchors is obtained from the relation,

$$s = P_a/T \qquad ...(20.54)$$

where T = tension in sheet pile per unit length as obtained from the analysis of anchored sheet pile.